Table 9. ESTIMATED USER-DAYS FOR CERTAIN FISH AND WILDLIFE SPECIES IN THE WILLAMETTE BASIN: 1965[a].

Resource	Species	User-days	Value of resource, dollars
Fish	Stream fish	735,300	
	Lake and pond fish	19,900	
	Reservoir fish	238,500	5,000,000
Big game	Deer	310,000	
	Elk	8,000	
	Black bear	6,000	
	Mountain lion	2,000	3,000,000
Upland game	Pheasant	182,500	
	Quail	55,000	
	Grouse	16,600	
	Mourning dove	35,600	
	Band-tailed pigeon	25,900	
	Rabbit	15,000	
	Squirrel	6,400	1,500,000
Waterfowl	Ducks	84,800	
	Geese	26,400	700,000
TOTAL		1,767,900	10,260,000[b]

[a] Estimates based on Oregon State Game Commission data and adapted from reference 30.

[b] Includes $60,000 as value of pelts from furbearing animals.

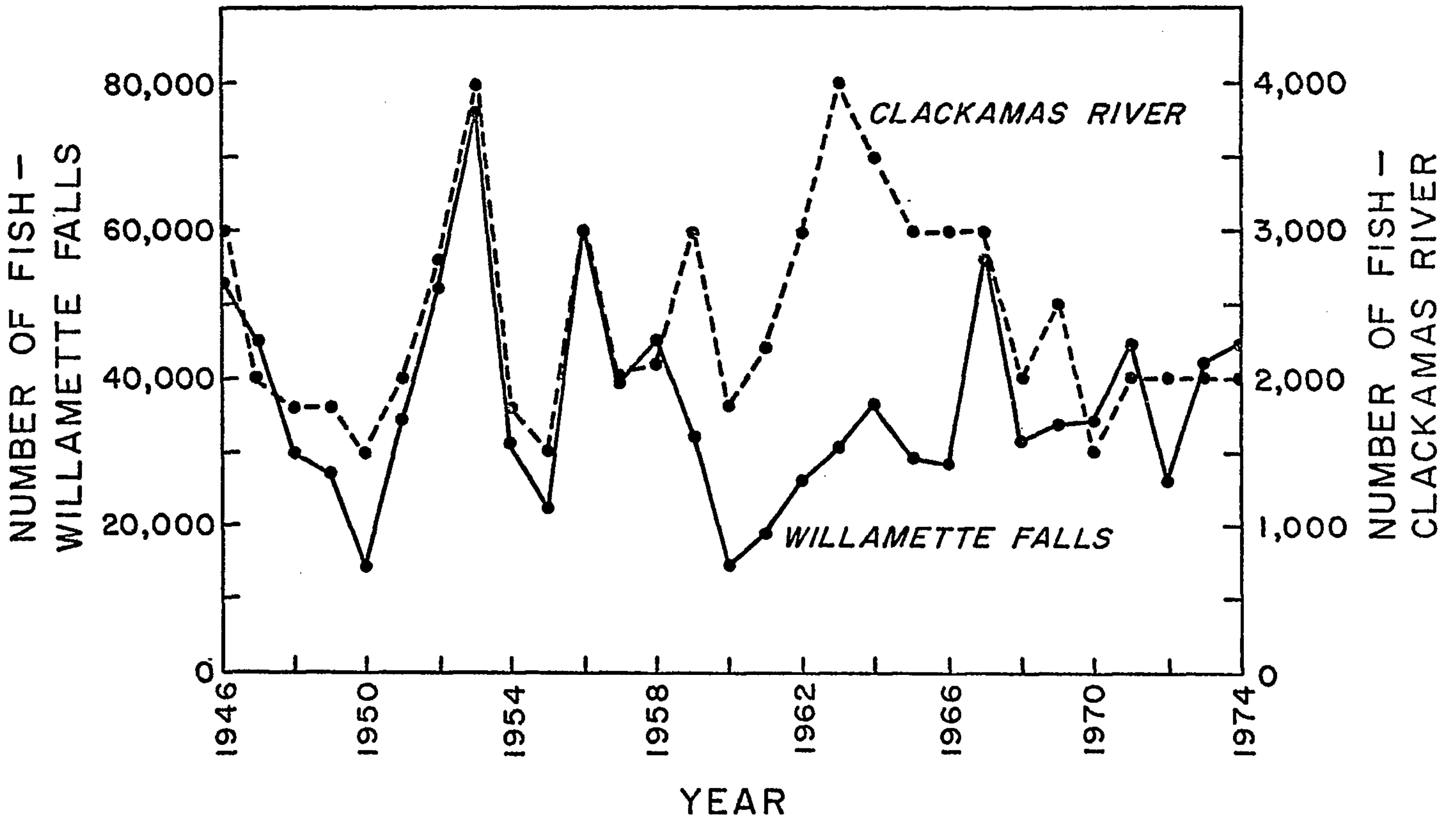

Figure 7. Calculated escapement of spring chinook salmon into the Clackamas River compared to the total migration of spring chinook salmon over Willamette Falls: 1946-1974.[31,32]

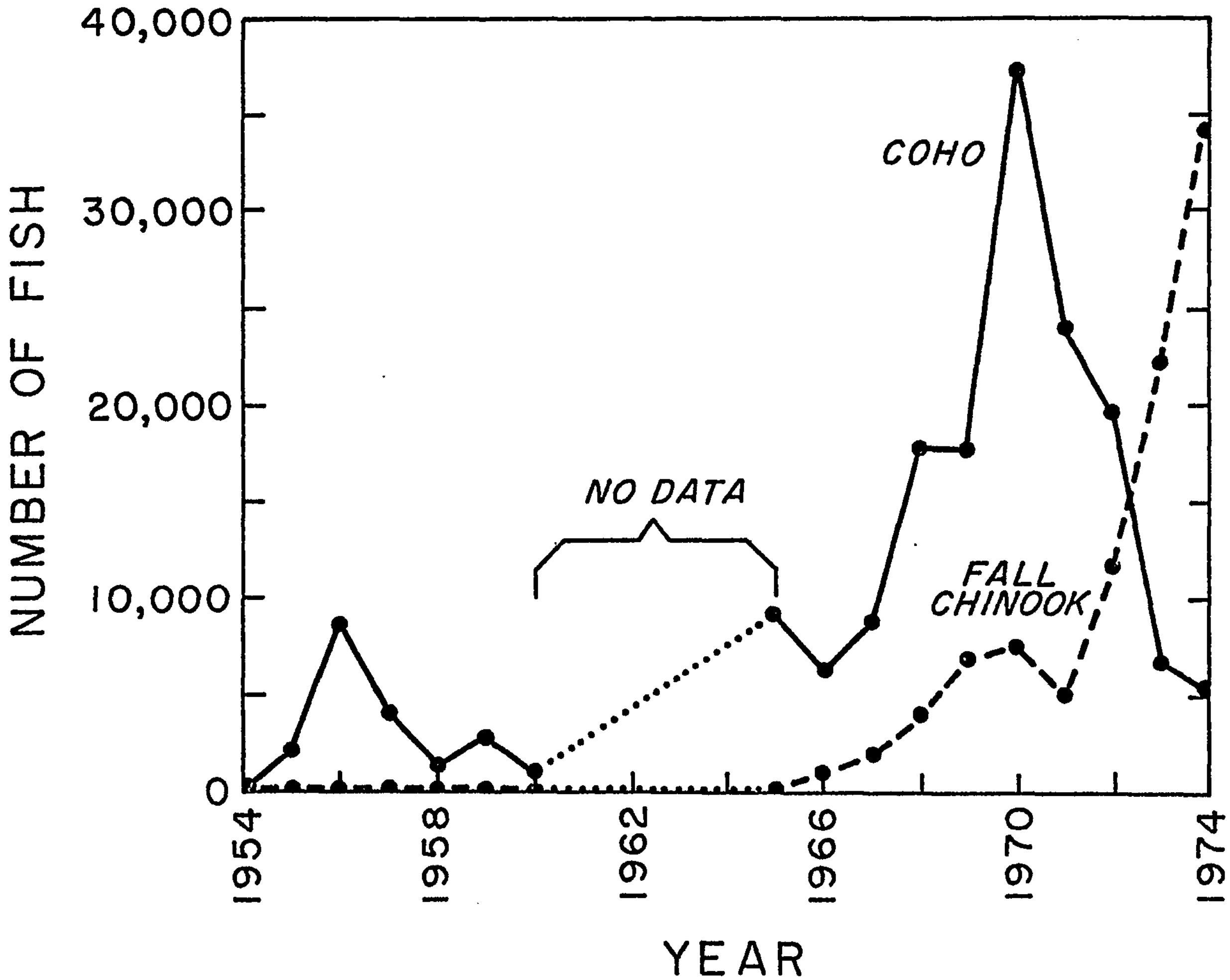

Figure 8. Calculated migration of coho and fall chinook salmon over Willamette Falls: 1954-1974.[31,32]

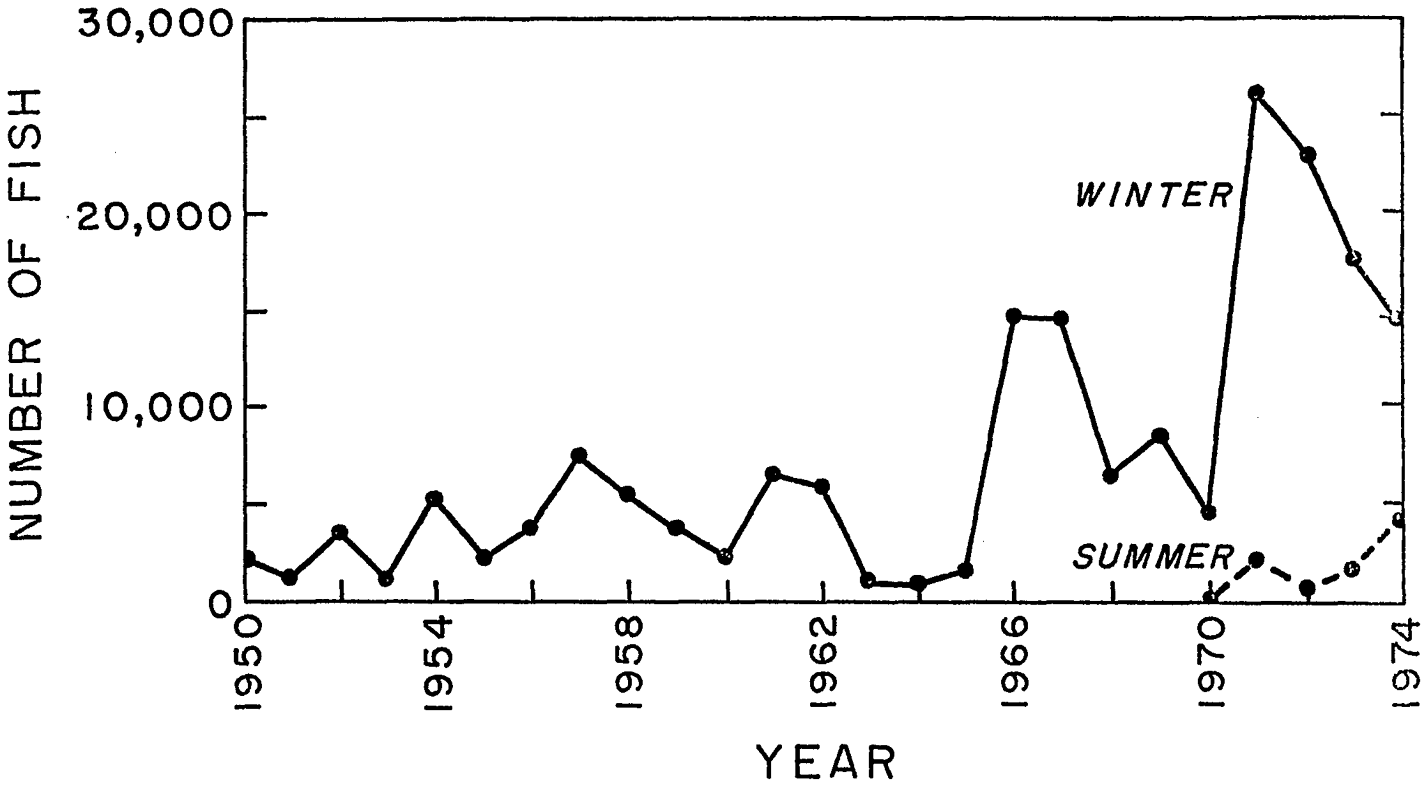

Figure 9. Calculated migration of winter and summer steelhead over Willamette Falls: 1950-1974.[31,32]

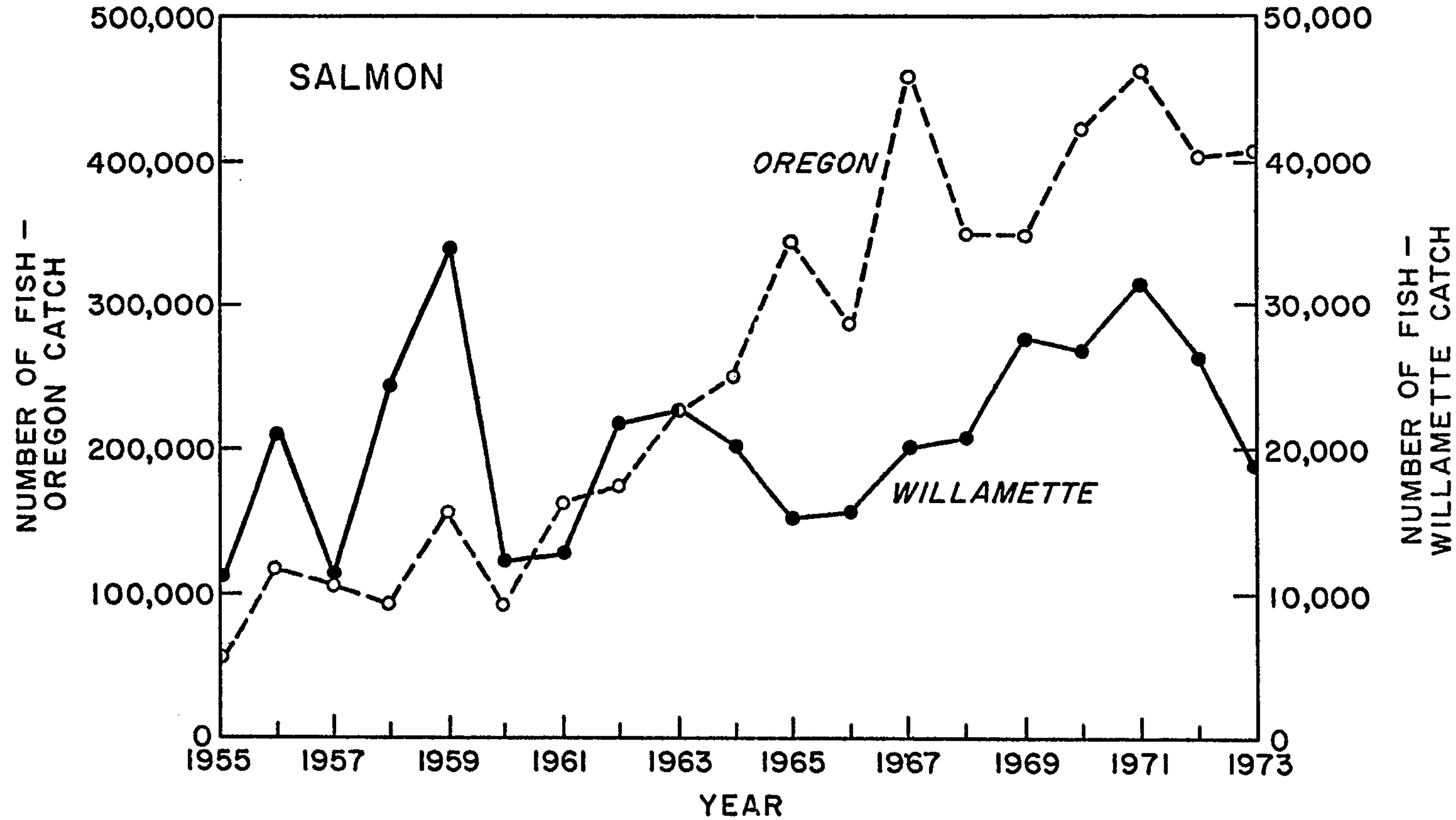

Figure 10. Estimated total sport catch of salmon in Oregon compared to the estimated sport catch of salmon from principal Willamette River tributaries: 1955-1973.[33]

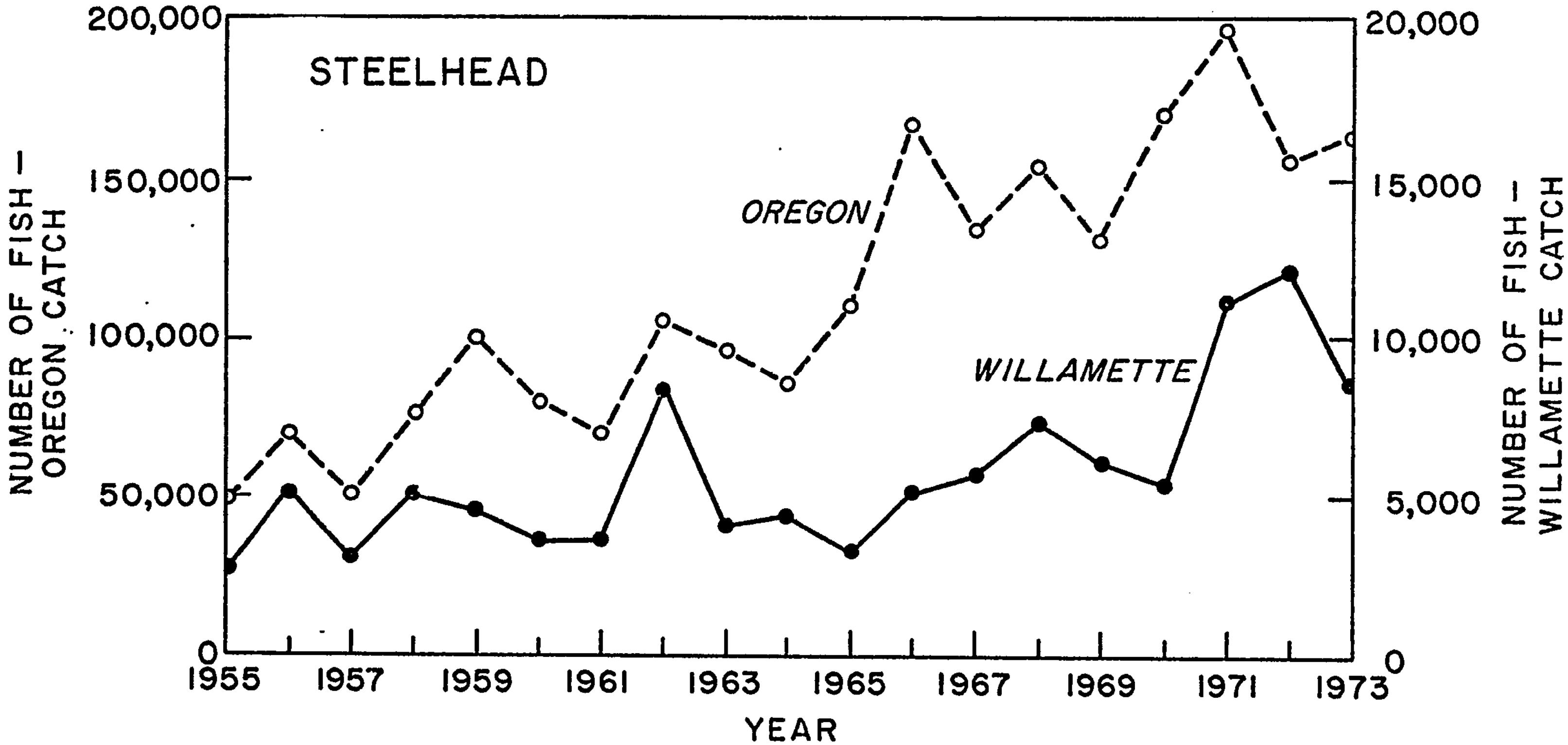

Figure 11. Estimated total sport catch of steelhead in Oregon compared to the estimated sport catch of steelhead from principal Willamette River tributaries: 1955-1973.[33]

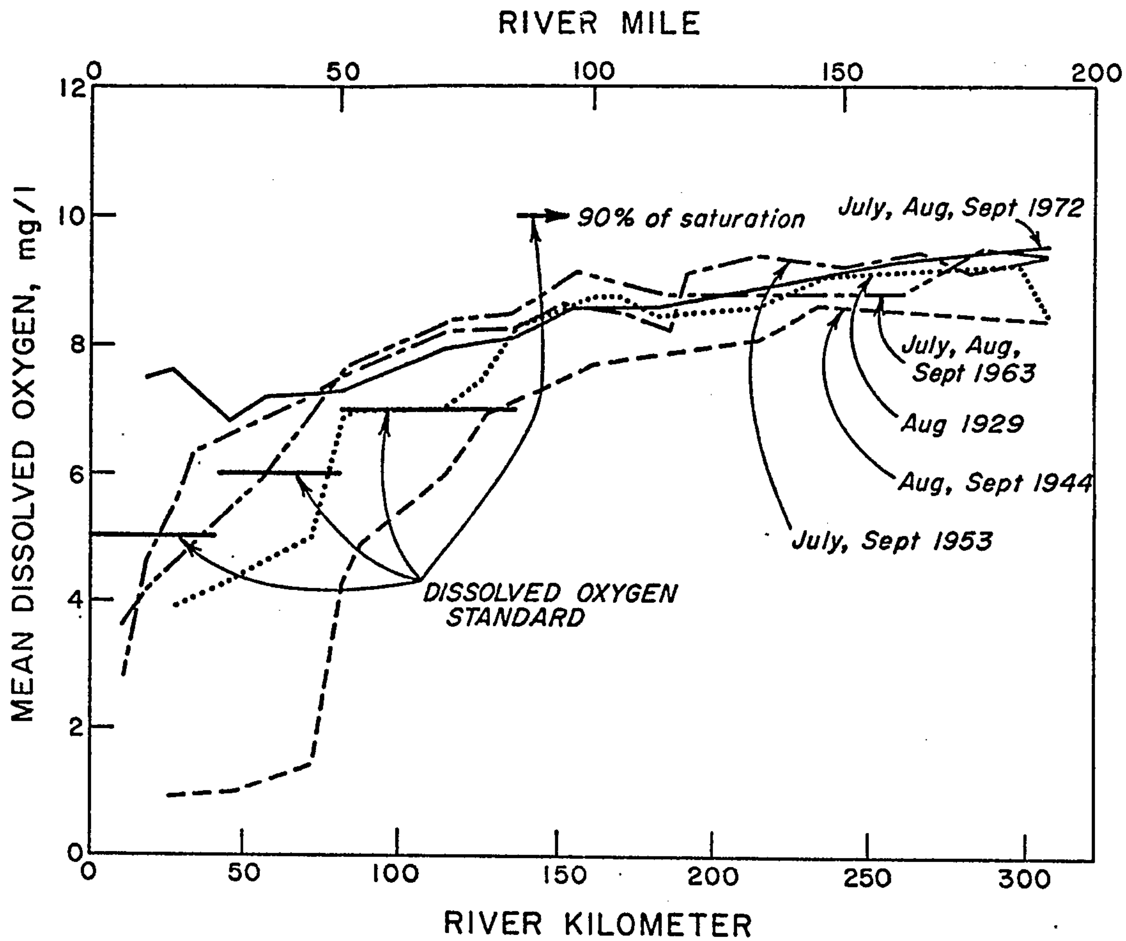

Figure 12. Mean dissolved oxygen concentrations for summer months in the Willamette River at selected locations and years.

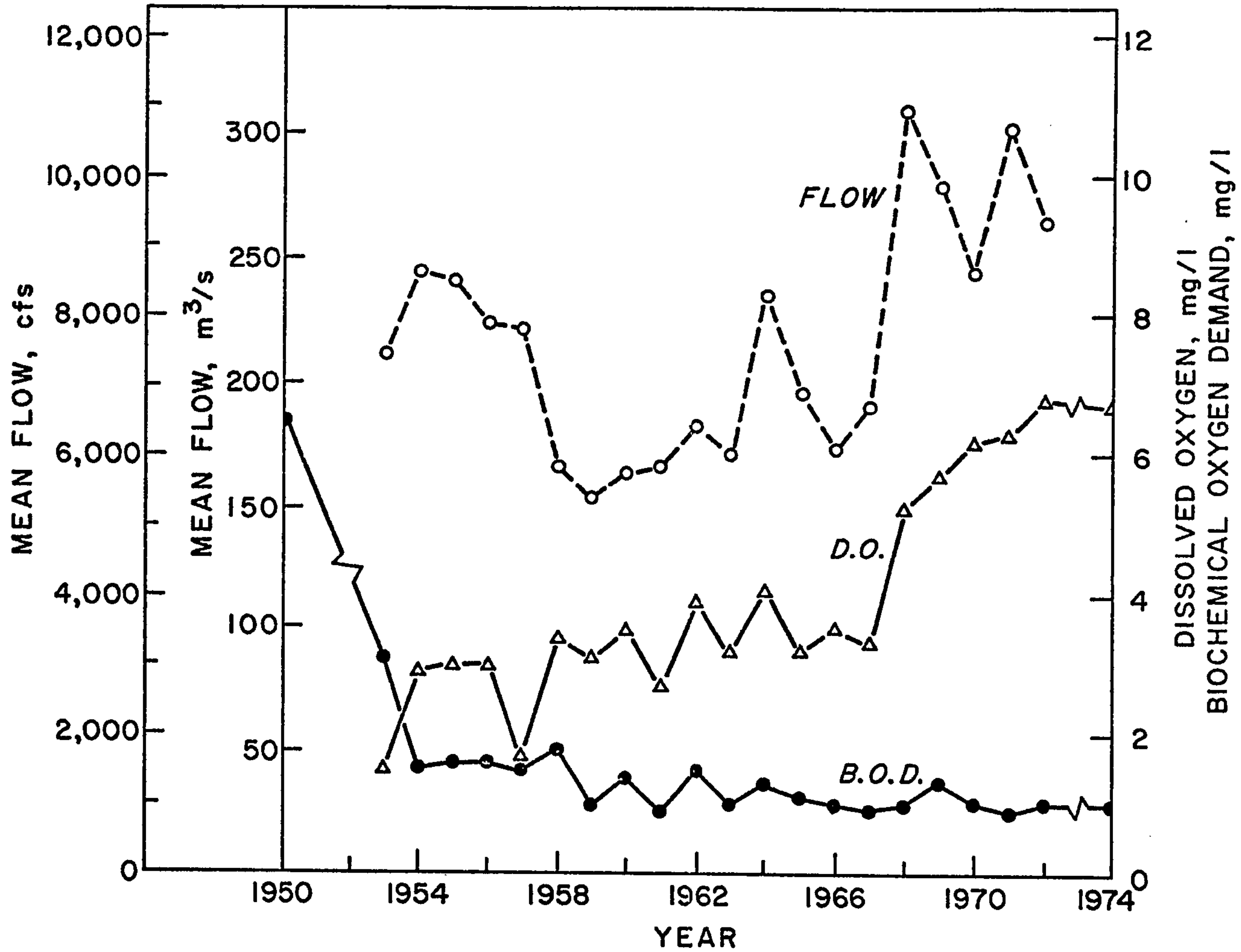

Figure 13. Mean flow, dissolved oxygen concentration, and 5-day biochemical oxygen demand of the lower Willamette River at the Spokane, Portland, and Seattle Railroad bridge during August 1950-1974.[34]

Undoubtedly both activities were instrumental in helping to improve the oxygen concentration.

With the prospects of continued improvement in water quality and the completion of vastly improved fish passage facilities at Willamette Falls, the Fish Commission of Oregon initiated a 9-year plan to fully develop the salmon and steelhead potential of the Willamette River. The plan was first made public in 1969[35] and was formally developed in 1970[35]. The individual and combined annual benefits to Oregon from full development of the potential in the Willamette River for self-sustained natural production of fall chinook and coho salmon and summer and winter steelhead are presented in Table 10. In fiscal 1971, the plan was implemented and jointly funded by the National Marine Fisheries Service and the Fish Commission of Oregon.[36,37] Data contained in Figures 8 and 9 indicate that the fall chinook salmon and summer steelhead programs have been highly successful to date. Winter steelhead show definite increases over the past ten years, while coho salmon decreased in abundance during the past two years. The decreases in coho are not surprising in view of similar drops in production throughout the northwest, indicating a problem in the oceanic environment rather than in their nursery and rearing areas.

Values for temperature and pH have been little affected by water pollution control, and apparently have had little influence on the migratory patterns of anadromous salmonids. Sams and Conover[25] reported that temperatures as high as 23°C (73°F) did not prevent salmon from entering the Willamette River from cooler water in the Columbia River. Not since 1958 has the August mean temperature been higher than 23°C (73°F) at the Spokane, Portland and Seattle Railroad bridge. Also, the increased flow pattern since 1968 does not appear to be associated with any general change in temperature at the same location. Likewise, pH has remained at 6.7 - 6.9 during the last 20 years.

Recreational use of the Willamette River and its immediate environment has been increasing, and based on data collected in 1970 is predicted to double in 20 years (by 1990). For example, in 1970 anglers participated in 603,000 recreational-days while catching 759,000 fish. By 1990, the number of recreational-days devoted to angling in the Willamette Basin is predicted to increase to 1,410,000.[26] Personnel of the Oregon State Highway Division estimated that swimming, water skiing, boating, and other water-related activities accounted for 8,000,000 activity-days in the Willamette River during 1970. This number is projected to increase to 16,000,000 by the year 1990.[38] Use of State parks on the Willamette River has increased from 398,000 to 627,000 visitor-days during the period 1969-70 to 1973-74, respectively.[37] Certainly all the increased use of the Willamette River and its related environments cannot directly be attributed to aquatic pollution abatement. It would equally be unjust to maintain that quality of the River has no effect on recreational use.

Table 10. BENEFITS TO OREGON OF FULL DEVELOPMENT OF THE POTENTIAL IN THE WILLAMETTE RIVER FOR SELF-SUSTAINED NATURAL PRODUCTION OF FALL CHINOOK AND COHO SALMON AND SUMMER AND WINTER STEELHEAD[a]

Species	Fishery	Benefit[b]	Present status	Potential for increase	Total potential
Fall chinook salmon	Commercial	Number of fish	3,000	72,000	75,000
		Processed value[c]	$ 28,000	$ 675,000	$ 703,000
	Sport[d]	Number of fish	600	15,000	15,600
		Gross economic value	$ 6,000	$ 150,000	$ 156,000
		Number of angler-days	600	15,000	15,600
Coho salmon	Commercial	Number of fish	20,000	45,000	65,000
		Processed value	$ 80,000	$ 180,000	$ 260,000
	Sport	Number of fish	7,000	15,000	22,000
		Gross economic value	$ 90,000	$ 200,000	$ 290,000
		Number of angler-days	9,000	20,000	29,000
Summer steelhead	Commercial	Number of fish		3,000	3,000
		Processed value		$ 10,003	$ 10,000
	Sport	Number of fish		25,000	25,000
		Gross economic value		$1,000,000	$1,000,000
		Number of angler-days		100,000	100,000
Winter steelhead	Commercial	Number of fish	1,000	1,500	2,500
		Processed value	$ 6,000	$ 8,000	$ 14,000
	Sport	Number of fish	3,200	4,400	7,600
		Gross economic value	$125,000	$ 175,000	$ 300,000
		Number of angler-days	12,500	17,500	30,000

Total potential increase in numbers	180,900
Total potential increase in value	$2,398,000
Total potential increase in angler-days	152,500

[a] Modified from reference 35.

[b] This does not include hatchery production or potential production in reservoirs or in streams above impassable dams, falls, or other barriers to upstream migrant adults.

[c] Based on 1968 prices.

[d] Total expenditures by sport fishermen, but excluding the cost of fishing licenses and salmon steelhead punch cards. Based on 1962 dollars.

Augmented summer flows have been beneficial to resident trout populations. The increased flows provide greater feeding and breeding areas, as well as help maintain stream temperatures at a more favorable level. Another benefit of cooler water has been the reduction in production of so-called "trash fish". In addition, control of flooding has decreased entrapment of salmonids in flood plain potholes.

A particularly significant demonstration of the cumulative beneficial environmental impacts of pollution control and water quality restoration is the so-called Willamette Greenway plan. The plan was conceived in 1966, at a time when the recovery of Willamette River water quality could be seen to be attainable in the near future, and called for a Willamette River Park System. A law was enacted in 1967 "to protect and preserve for present and future generations...the natural scenic and recreational value of the Willamette River" by establishing riverbank parks along the Willamette. Recreational use of the River has greatly increased since 1966, particularly by kayak, canoe and waterski enthusiasts. The Greenway plan represents a sizeable financial commitment by the State (with some Federal matching funds) to protect the re-established recreational, fishery and wildlife values which have resulted from the pollution control strategies utilized to date. The Greenway is both a commitment and a statement of faith to the future protection of the recovered water quality in the Willamette River.

Adverse Effects

At least 190 km (120 mi) of free-flowing streams have been inundated by reservoirs whose naked and muddy banks are regularly exposed by annual draw-downs.[40] The aesthetic loss of such natural habitats on principal tributaries to the Willamette River cannot adequately be replaced by any type of mitigation. Coomber and Biswas[41] quoting Starker Leopold point out that, "For things society judges to be desirable, relative scarcity or uniqueness increases value to society."

"In Western Oregon, water impoundments are detrimental to big game. Key winter ranges and migration routes normally coincide with reservoir sites. Game population densities relying on these lowland stream bottom areas commonly are several times the densities occurring elsewhere. The seasonal, altitudinal migrations of deer and elk along streams have been blocked by the construction of impoundments and has caused them to remain at high elevations during the winter.[29] Populations of furbearing animals which normally thrive in the flood plain have adversely been effected by flood control. Likewise, populations of ducks which formerly nested in flood plain potholes have been effected.

Turbidity, especially in Hills Creek Reservoir, has been identified as a biological, aesthetic and economic problem involving problems with fish and wildlife, recreation, and other uses of the impoundment.[42]

These authors speculated that low quantities of organic matter, which adversely effect basic productivity, may indeed be related indirectly to the turbidity of the water.

Chlorination of municipal wastewaters is the cheapest and most effective general method of wastewater disinfection in the United States. Generally recommended concentrations for residual chlorine are between 0.5 and 1.0 mg/l.[43] Chlorine, however, is an extremely powerful biocide and a major toxicant in sewage which eliminates pathogens but also damages fish and other aquatic organisms. The presence of chlorine below sewage outfalls is often noticeable by odor and by degradation of living stream bed organisms.[44]

Although fish are repelled by low levels of chlorine in water and frequently can escape in time, other aquatic organisms in the food chain may be eliminated. Brungs,[43] in Table 11, shows acute and chronic effects of residual chlorine on aquatic life.

The Oregon DEQ requires residual chlorine levels of 1 mg/l to ensure that fecal coliforms levels are maintained below 200 organisms/100 milliliters (ml). Many wastewater treatment plant operators, probably operating on the assumption that if a little chlorine is good a lot is great, overchlorinate. Monthly averages of residual chlorine in treatment plant effluents as high as 9 mg/l have been recorded. Proper surveillance of disinfection practices and increased operator education regarding both the positive and negative aspects of chlorination could mitigate this problem.

Summary

The net environmental impacts of the Willamette River cleanup are wide ranging. The effects of the restoration on some fish and wildlife species have been briefly described here; but obviously many other effects--biological, physical, aesthetic--which deny quantification have not been dealt with.

The impacts of water quality control programs extend far beyond the water phase of our environment. Many aspects, such as transportation, land use, and air quality, are involved in water quality management and these parameters must also be considered so that the net impact of environmental protection plans is a positive one.

Table 11. SELECTED SUMMARY OF ACUTE AND CHRONIC TOXIC EFFECTS OF RESIDUAL CHLORINE ON AQUATIC LIFE[a]

Species	Effect endpoint	Measured residual chlorine concentration, (mg/l)
Coho salmon	7-day TL_{50}[b]	0.083
Pink salmon	100% kill (1-2 days)	0.08-0.10
Coho salmon	100% kill (1-2 days)	0.13-0.20
Pink salmon	Maximum nonlethal	0.05
Coho salmon	Maximum nonlethal	0.05
Brook trout	7-day TL_{50}[b]	0.083
Brook trout	Absent in streams	0.015
Brown trout	Absent in streams	0.015
Brook trout	67% lethality (4 days)	0.01
Brook trout	Depressed activity	0.005
Rainbow trout	96-hour TL_{50}[b]	0.14-0.29
Rainbow trout	7-day TL_{50}[b]	0.08
Rainbow trout'	Lethal (12 days)	0.01
Trout fry	Lethal (2 days)	0.06
Yellow perch	7-day TL_{50}[b]	0.205
Largemouth bass	7-day TL_{50}[b]	0.261
Smallmouth bass	Absent in streams	0.1
White sucker	7-day TL_{50}[b]	0.132
Walleye	7-day TL_{50}[b]	0.15
Black bullhead	96-hour TL_{50}[b]	0.099
Fathead minnow	96-hour TL_{50}[b]	0.05-0.16
Fathead minnow	7-day TL_{50}[b]	0.082-0.115
Fathead minnow	Safe concentration	0.0165
Golden shiner	96-hour TL_{50}[b]	0.19
Fish species diversity	50% reduction	0.01
Scud	Safe concentration	0.0034
Scud	Safe concentration	0.012
Daphnia magna	Safe concentration	0.003
Protozoa	Lethal	0.01

[a] Adapted from reference 43.

[b] TL_{50} = median tolerance limit (50 percent survival).

SECTION VII

CAPITAL EXPENDITURES

INTRODUCTION

The objectives of this research contract included documenting the dollar and energy costs of constructing the pollution control facilities that have contributed to the cleanup of the Willamette River. In the early stages of the investigation, limitations were established on facilities and expenditures to be researched. Investigation of three major subject areas was undertaken.

One subject area was municipal wastewater collection, treatment, and release dealing mainly with domestic wastes but also including large quantities of industrial wastes handled by municipal systems. It was agreed among project members and EPA representatives to limit "collection" to those portions of sewerage systems designated as "interceptors". This was done for a number of reasons. Interceptors make up that portion of the system which prevents flows from the sewers, laterals, and trunks from passing untreated into the receiving water and generally convey the flows "downstream" to the treatment plant. The Federal government's financial participation in water pollution abatement is generally limited to interceptors, treatment works, and outfalls and excludes portions above or "upstream" of interceptors. Also, reported expenditure data generally followed the above definitions. Municipal wastewater "treatment" included treatment works as well as the treating and disposing of associated sludges. "Release" covered outfall and diffuser works at the plant and at upstream overflow points.

The second subject area involved industrial water pollution abatement. This included the collection, treatment, and disposal of various waste streams, as well as in-process modifications reducing, concentrating, or eliminating certain wastewaters.

The final subject area investigated was reservoirs. This part of the research was confined to the thirteen Corps of Engineers' impoundments as it was felt that smaller, private industry or utility dams had relatively negligible downstream water quality impacts.

Limitations were also set as to what type of expenditures at these facilities would be investigated. Construction costs (economic and energetic) were researched in depth. Design costs of municipal systems were estimated; these figures are included in the capital cost table appended to this report. Lands costs were not considered. All cost adjustments were made using the Construction Cost Index published in the "Engineering News Record".

At this point it would be well to mention certain types of expenditures which have been omitted from analysis. First, under municipal systems, no portions of the collection system above interceptors have been investigated (although some parts may have entered the picture either by a misunderstanding by municipal officials of the definition of the word "interceptor" or in those cases where a reported construction award amount was for a joint project, e.g., interceptors and trunks). Second, for industrial activities, many small firms were eliminated from the research. The reasons for that are discussed in subsequent paragraphs. A third omission is that of the energy costs of engineering services. Finally, the costs of administrative actions by federal, state, and local regulatory agencies have not been taken into account.

INVENTORY OF FACILITIES

Table 12 is a list of municipal wastewater treatment plants operating in the Willamette Valley. The table includes information regarding plant type, the year each was put in operation or underwent its last major expansion or addition, design capacity in terms of population equivalents and flow, and location of discharge point. Table 13 is a compilation of those plants from Table 12 having significant industrial or commercial flow contributions.

Table 14 presents information similar to that in Table 12 for domestic sewage treatment plants which have been abandoned. Most of these plants were abandoned in favor of larger regional plants and the new receiving plant is named if known, Several points should be made here. First, while the approximately seventy abandoned plants seem significant when compared to the one-hundred thirty or so currently operating plants, their capital costs represent less than two percent of all treatment plant capital costs. Secondly, the short period of operation at many of these plants should be noted. Most operated less than ten years and many for less than five. While these plants represent a small portion of the total, they do represent a lack of full lifetime utilization. Finally, it should also be made clear that these lists are by no means firm. New plants are under construction and many existing plants will be phased out within the next decade.

Table 15 is a list of the twenty largest industries having their own treatment works. Thirteen have waste streams which are organic in nature (e.g., the pulp and/or paper manufacturers) while seven have inorganic wastes (e.g., the metal producers). The reader should be aware that many more industries are located in the Willamette Valley. These include companies having their own treatment facilities and outfalls (e.g., many sawmills and plywood and veneer operations) as well as those firms which discharge to municipal systems (e.g., many food processors), possibly following some degree of pretreatment. The

Table 12. OPERATING MUNICIPAL SEWAGE TREATMENT PLANTS

Plant	Type[a]	Year built	Design domestic population equivalent	Design m^3/day[b]	Receiving stream river kilometer[a,c]
Adair	TF	1959	750	760	S1 to Willamette
Albany	AS	1969	40,700	33,000	Willanette-191.5
Aloha	AL-EF	1973	40,000	15,000	Beaverton Cr.-5.3
American Can Co.	AL	1969	310	120	Willamette-238.8
Amity	L	1968	1,000	380	Ash Swale Cr.-2.4
AP Industrial Park	EA-L	'1969	75	30	Columbia S1
Aumsville	L	1971	1,660	630	Beaver Cr.-4.0
Banks	EA	1936 1967	1,050	530	W. Fk. Dairy Ck.-16.1
Beaverton	TF-EF	1963	14,000	6,100	Beaverton Cr.-12.9
Brownsville	L	1965	1,290	490	Calapooia-50.8
Burright Subdivision	EA	1964	90	34	Mitchell Cr.
Canby	As	1971	6,000	3,200	Willamette-53.1
Carlton	TF	1955	1,500	1,100	N Yamhill-9.7
Cedar Hills	TF	1962	13,000	4,900	Beaverton Cr.-12.1
Central Linn H.S.	EA	1958	100	30	Spoon Cr.-7.1
Century Meadows	EA	1972	400	150	Willamette-67.6
Chatnicka Heights	EA	1964	400	150	Glenn Cr. to Winslow Cr.-7.2
Chemewa Indian School	AL	1965	1,450	550	Labisch Ditch
Columbia Way Court	EA	1971	175	66	Ditch to Columbia S1
Cornelius	TF	1959	2,500	950	Tualatin- 84.2
Corvallis	TF	1966	52,440	27,000	Willamette-210.8
Corvallis Airport	L	1962	100	38	Cr to Willamette-222.0
Corvallis Mobile Park	EA	1959	250	49	Oak Cr- 2.6
Cottage Grove	TF	1967	10,000	5,700	Coast Fork Willamette-35.4
Country Squire Motel	EA-L	1964	650	250	Muddy Cr.- 77.2
Creswell	L	1962	1,750	660	Camas Sw.-8.0
Dallas	AS	1969	15,400	7,600	Rickreall Cr-16.9
Dammasch Hospital	TF	1960	2,500	1,100	Corral Cr.-1.6

Table 12 (continued). OPERATING MUNICIPAL SEWAGE TREATMENT PLANTS

Plant	Type[a]	year built	Design domestic population equivalent	Design m^3/day	Receiving stream river kilometer [a,c]
Dayton	L	1965	1,000	380	Yamhill-8.0
Dike Side Moorage	EA	1973	60	23	Multhomah Ch-19.3
Diamond Hill	L	1966	135	53	Little Muddy Cr.
Dundee	L	1971	1,350	510	Willamette-83.7
Eola Village	TF	1941	1,300	250	S Yamhill-24.1
Estacada	TF	1963	2,500	1,400	Clackamas-38.0
Eugene	TF	1965	106,500	65,000	Willamette-286.4
Eugene Airport	L	1964	150	57	Clear Lake Cr.
Fanno Creek	AS	1969	30,000	11,000	Fanno Cr.-13.4
Fir Cove	P	1957	300	57	Coast Fork Willamette-1.6
Forest Grove	TF-L	1965 1974	30,000	19,000	Tualatin-91.6
Gaston	EA	1964	500	230	Tualatin-103.8
Gervais	L	1965	650	250	Ditch to Pudding-48.3
Goshen School	L	1966	70	26	Wild Hog Cr-1.1
Gresham	As	1973	30,000	23,000	Columbia R-189.1
Halsey	L	1969	800	360	Muddy Cr.-37.0
Harrisburg	TF	1967	2,000	950	Willamette-259.0
Hayden Island Mobile Home	EA	1972	6,000	2,300	Oregon S1 to Columbia-170.6
Hemlock Subdivision	EA	1966	300	110	M Fork Willamette
Hillsboro-West	As	1971	20,000	7,600	Tualatin-59.5
Hillsboro-Rock Cr.	AS	1974	30,000	11,000	Rock Cr.-0.8
Hubbard	TF	1968	2,000	760	Mill Cr.-8.5
Illahee Hills	L	1962	500	230	Cr to Willamette-138.4
Independence	L	1967	3,850	1,500	Ash Cr.-2.1
Inverness	EA	1969	20,000	7,600	Columbia-182.6
Jefferson	L	1969	1,080	410	Santiam-11.3
Jubitz Truck Stop	EA	1964	50	19	Columbia S1
Junction City	L	1967	3,500	4,100	Flat Cr. to Crow Cr.-7.2

Table 12 (continued). OPERATING MUNICIPAL SEWAGE TREATMENT PLANTS

Plant	Type[a]	Year built	Design: domestic population equivalent	Design: m^3/day[b]	Receiving stream river kilometer [a,c]
King City	EA	1970	2,300	1,000	Tualatin R.
Lafayette	L	1964	1,000	380	Yamhill-12.9
Lafayette Trappist Fndn.	TF	1956	150	42	Cr to Yamhill
Lane Community College	L	1967	1,420	540	Russell Cr.
Laurelwood Academy	TF	1967	400	190	Hill Cr.-9.7
Lebanon	TF	1958	7,500	7,200	S Santiam-28.0
Lowell	TF	1949	3,200	980	Mid Fork Willa-mette-29.8
Lowell Park	EA	1960	120	30	Mid Fork Willa-mette-27.2
Marylhurst	TF	1962	1,100	420	Willamette-35.2
McMinnville	AS	1970	21,600	15,000	S Fork Yamhill-6.4
Metzger	AS	1966	25,000	9,500	Fanno Cr.-7.9
Millersburg School	L	1966	90	34	Crooks Cr.-10.0
Milwaukie	AS	1962	14,000	7,600	Willamette-29.0
Molalla	TF	1955	3,000	1,500	Bear Cr.-0.8
Monmouth	L	1964	7,000	2,600	Ash Cr.- 4.2
Monroe	L	1968	520	200	Long Tom-10.5
Mntn. St. Inv.-Airport Pk	EA-EF	1969	500	190	Columbia S1
Mt. Angel	TF	1955	2,000	1,400	Pudding-55.8
Newberg	AS	1963	10,000	7,600	Willamette-80.9
Oak Acres Trailer Park	EA	1962	300	110	Subsurface
Oak Hills	EA-L	1965	2,000	760	Willow Cr.-4.3
Oak Lodge San. Dist.	AS	1969 1973	15,000	15,000	Willamette-32.3
Oakridge	AS	1969	4,200	1,600	Mid Fork Willa-mette-64.0
Oregon City	AS	1964	10,000	11,000	Willamette-40.5
Oregon Primate Res. Ctr	EA-L	1964	600	230	Bronson Cr.-1.6
Panavista Subdivision	EA	1966	100	38	Cr to Cedar Mill Cr
Philomath	AS	1972	3,500	1,300	Mary's R-18.5
Pineway Apartments	EA-L	1964	50	19	S Santiam

Table 12 (continued). OPERATING MUNICIPAL SEWAGE TREATMENT PLANTS

Plant	Type[a]	Year built	Design domestic population equivalent	Design m^3/day	Receiving stream river kilometer
Pioneer Villa	EA	1963	75	30	Courtney Cr.
Pleasant Valley School	EA	1963	130	49	Mitchell Cr.
Portland-Columbia	P	1974	1,100,000	378,000	Columbia-169.7
Portland-Tryon Creek	AS	1965	31,000	19,000	Willamette-32.7
Portland Mobile Home Ct.	TF	1972	620	230	Columbia S1
Propco	EA	1968	150	57	Columbia S1
Ramada Inn	EA-L	1965	280	68	Tualatin-12.9
River Bend Mobile Park	EA	1970	500	190	Clackamas-11.3
Riverview Heights	EA	1960	400	190	Dr to Willamette-185.0
Riverview Mobile Ranch	EA	1971	500	190	Clackamas-12.1
River Village Mobile Park	EA	1963	60	30	Willamette-64.4
Royal Highlands	EA	1961	75	30	Small Cr.
St. Helens	P	1959	10,000	11,000	Aerated Lagoon
St. Helens	AL	1971	340,000	110,000	Columbia-138.4
Salem-Willow Lake	TF	1964	73,900	66,000	Willamette-125.8
Salem-West	EA	1969	4,000	1,500	Willamette-128.7
Sandy	AS	1972	5,000	1,900	Trickle Cr.-2.1
Sauvie Island Moorage	EA	1971	75	28	Multnomah Cr-30.6
Scappose	AS-L	1973	5,000	1,900	Multnomah Cr-16.9
Scio	L	1969	600	230	Thomas Cr.-12.9
Sheridan	L	1973	5,250	2,000	S Fork Yamhill-59.5
Sheridan' Novitiate	TF	1956	200	57	S Fork Yamhill
Sherwood	TF	1965	1,000	2,200	Cedar Cr.-1.8
Silverton	TF	1969	4,000	2,600	Silver Cr.-5.6
Skyline West S. D.	L	1968	310	91	Oak Cr.
Somerset West	EA-L	1964 1974	1 ,600	1,200	Beaverton Cr-12.1
Southwood Park S. D.	TF	1962	1,000	380	Ball Cr.-1.9
Springfield	TF	1962	36,000	26,000	Willamette- 296.5
Stayton	EA-EF	1964 1973	13,500	5,100	N Santiam- 24.1

Table 12 (continued). OPERATING MUNICIPAL SEWAGE TREATMENT PLANTS

Plant,	Type[a]	Year built	Design domestic population equivalent	Design m^3/day[b]	Receiving stream river kilometer[a,c]
Stephenson School	EA	1965	60	19	Tryon Cr.
Stuckey's Pecan	L	1969	70	26	Courtney Cr.
Sunset Valley	As	1965	10,900	5,700	Cedar Mill Cr-4.8
Sweet Home	AS-EF	1974	12,000		S Santiam-54.1
Tangent School	EA	1965	36	30	Cr to Lake Cr.
Tektronix	EA	1963	4,000	980	Beaverton Cr-11.3
Tigard	TF-AS	1970	11,400	5,700	Fanno Cr.-6.0
Timberlakes Job Corps	EA-L	1969	300	190	Clackamas R.
Tualatin	EA-EF	1970	3,500	1,100	Tualatin-13.8
Tualatin Valley Devel. Co,	EA	1965	2,000	760	Tualatin-17.7
Twin Oaks School	TF	1958	120	34	Subsurface Spencer Cr.-7.7
Veneta	L	1971	300	38	Long Tom-48.3
West Hills San. Dist.	EA	1961	300	110	Squaw Cr.
West Linn-Bolton	TF	1963	7,000	4,900	Willamette- 38.8
West Linn-Willamette	TF	1963	2,500	1,400	Wlillamette-45.1
West Tualatin View School	TF	1968	100	38	Subsurface
Willamette Lutheran Homes	L	1962	175	76	Clear Lake
Willamina	L	1966	2,000	760	Willamina Cr-0.8
Willow Island Mobile Est.	EA-L	1973	300	110	Willamette
Wilsonville	EA	1972	5,000	1,900	Willamette-62.8
Woodburn	TF-L	1973	9,560	4,000	Pudding-13.7
Yamhill	EA	1964	750	380	Yamhill Cr.4.4

[a] Abbreviations:
AL - Aerated Lagoon
AS - Activated Sludge
Cr - Creek
EA - Extended Aeration
EF - Effluent Filtration
L - Lagoon
P - Primary
Sl - Slough
SW - Swale
TF - Trickling Filter

[b] 1 m^3/day = 264 gpd.

[c] 1 kilometer = 0.622 miles.

Table 13. MUNICIPAL SEWAGE TREATMENT PLANTS WITH MAJOR INDUSTRIAL LOADS[a]

Plant	Design population equivalent		1974 loadings	
	Domestic	Industrial	Domestic	Industrial
Albany	40,700	187,300	21,000	199,000
Corvallis	52,440	95,300	37,900	80,100
Dallas	15,400	20,000	7,000	---
Eugene	106,500	222,000	90,100	404,900
Forest Grove	11,400	129,600	9,670	22,330
Gresham	30,000	10,000	23,800	16,200
Junction City	3,500	4,200	2,600	---
McMinnville	21,600	25,400	12,500	4,900
Mt. Angel	2,000	3,000	2,200	---
Newberg	12,500	3,500	7,000	5,000
Oregon City	10,000	46,000	20,000	5,000
Portland	b	b	385,000	235,000
St. Helens	10,000	330,000	6,000	381,000
Salem	73,900	381,100	100,000	500,000
Sherwood	1,000	4,500	2,850	1,150
Silverton	4,000	16,000	4,550	2,150
Springfield	36,000	4,000	33,000	2,500
Tigard	11,400	1,400	12,200	800
Tualatin	2,455	1,240	2,650	3,600

[a] Data from reference 9 with updates provided by cities and DEQ.

[b] Designed hydraulically for 378,000 m^3/day (100 mgd).

Table 14. SEWAGE TREATMENT PLANTS NO LONGER OPERATING

Plant	Years operational	Design m^3/day[a]	Design PE	Type of Plant[b]	Original receiving stream	Flows to now
Aloha-Huber	'55-'67	38	500	TF	Beaverton Creek	Aloha
Bailey Hill School	'63-'67	30	300	EA	Ditch	Eugene
Baker Bay	'64-'70	30	1,000	EA	Dorena Reservoir	Ground
Beaver Acres School	'56-'67	38	100	TF	Beaverton Creek	Aloha
Bel-Aire Subdivision	'58-'63	170	450	TF-L	Fanno Creek	Beaverton
BOMARC (Corvallis)	'59-'61	57	150	EA	Willamette	None
Broadmoor	'48-'61	260	1,000	AS	Beaverton Creek	Fanno Creek
Brookford	'55-'61	380	1,000	AS	Fanno Creek	Fanno Creek
Cal Young School	'57-'66	42	580	ST	Willamette	Eugene
Camp Adair	'42-'49	5,100	35,000	P	Willamette	None
Cedar Mill Park	'47-'57	330	1,370	TF	Cedar Mill Creel	Sunset Valley
Columbia Sanitary District	'57-'66	380	1,000	AS	Fanno Creek	Fanno Creek
Country Club Homes	'58-'61	30	80	L	Beaverton Creek	Fanno Creek
Detroit Dam	'48-'53	1,200	3,150	TF	North Santiam	None[c]
Dorena Dam	'47-'53	95	500	ST-ISF	Ground	None[c]
Fannoe Park	'57-'61	30	60	EA	Fanno Creek	Fanno Creek
Furlong	'60-'64	450	1,200	TF	Cedar Mill Creel	Sunset Valley
Grande Ronde Housing	'43-'59	57	300	ST	Rock Creek	Subsurface

Table 14 (continued). SEWAGE TREATMENT PLANTS NO LONGER OPERATING

Plant	Years operational	Design		Type of Plant [b]	Original receiving stream	Flows to now
		m^3/day[a]	PE			
Green Peter Dam	'64-'74	7.6	20	EA	M Fk S Santiam	Sweet Home[d]
Hillsboro Junior High School	'63-'73	68	900	EA	Beaverton Creek	Hillsboro-Rock
Indian Hills	'63-'65	57	150	EA	Ditch	Portland-Tryon
Jesuit High School	'56-'61	30	500	EA	Beaverton Creek	Fanno Creek
Judson School	'58-'64	57	500	EA	Small Creek	Salem
Lewis & Clark College	'52-'66	450	1,200	P	Willamette	Portland-Tryon
MacLaren School	'53-'72	380	500	TF	Pudding R.	Woodburn
Manbrin Gardens	'47-'68	260	1,000	P	Willamette	Salem
Markham School	'51-'68	38	700	TF	Fanno Creek	Portland-Tryon
McGlassen Village	'62-'65	30	75	EA	Creek to Rock Cr	Aloha
Meadow Lark School	'60-'66	26	280	L	Ditch to Willamette	Eugene
Oak Grove School	'55-'62	76	1,000	TF	Creek to Willamette	Oak Lodge
Orchid	'58-'66	30	100	EA	Fanno Creek	Metzger
Orient Grade School	'54-'73	38	600	TF	Creek to Johnson Creek	Gresham[d]
Peerless Truck	'65-'73	30	75	EA	Tualatin R	Tualatin
Pinebrook Sanitary District	'65-'68	230	580	EA	Fanno Creek	Fanno Creek
Pioneer Trailer Park	'56-'67	30	120	EA	Beaverton Creek	Beaverton
Port of Portland	'41-'74	1,900	3,000	P	Columbia	Inverness
Raleigh Sanitary District	'57-'64	530	1,400	TF	Fanno Creek	Fanno Creek

Table 14 (continued). SEWAGE TREATMENT PLANTS NO LONGER OPERATING

Plant	Years operational	Design		Type of Plant[b]	Original receiving stream	Flows to now
		m^3/day[a]	PE			
Raleighwood Sanitary District	'56-'61	38	100	L	Fanno Creek	Fanno Creek
Rilco Corp.	'61-'72	38	200	TF	Coast Fk Willa-mette	Cottage Grove
Salemtowne	'67-'73	380	1,000	EA	Winslow Creek	West Salem
Salem						
Wulfer's Trailer	'59-'67	57	250	EA	Little Pudding	Salem
Alumina Plant	e		200		Ground	Salem
Hillcrest	f				Pringle Creek	Salem
State Farm	f				Ditch	Salem
Penet. Annex	f				Mill Creek	Salem
TB Hospital	f				Mill Creek	Salem
Fairview	f				Pringle Creek	Salem
Sugar Plum Sanitary District	'62-'67	57	150	TF	Butternut Creek	Aloha
Sunset Heights	'57-'67	19	500	TF	Beaverton Creek	West Slope SD
Sweet Home Housing	'43-'49	76	350	TF	Creek to Santiam	Sweet Home
Sylvan Heights	'64-'66	30	75	EA	Fanno Creek	Fanno Creek
Tahitian Terrace	'60-'63	34	120	EA	Creek to Fanno C	Fanno Creek
Thunderbird Trailer Park	'62-'72	57	285	EA-L	Creek to Willa-mette	Wilsonville
Tualatin Hills	'54-'66	450	1,000	TF	Fanno Creek	Metzger
Tualatin Slopes	'52-'55		100	ST	Subsurface	Uplands

Table 14 (continued). SEWAGE TREATMENT PLANTS NO LONGER OPERATING

Plant	Years operational	Design		Type of Plant[b]	Original receiving stream	Flows to now
		m^3/day[a]	PE			
Uplands	'60-'68	570	1,500	TF[g]	Johnson Creek	Sunset Valley
Vermont Hills Sanitary Dist.	'48-'57	38	140	ST-ISF	Fanno Creek	Portland-Columbia
West Hills Convalescent Home	'64-'70	57	150	EA	Fanno Creek	Portland-Columbia
West Tualatin View School	'56-'73	380	1,000	TF	Beaverton Cr.	Subsurface
Westmont	'60-'64	68	175	L	Cedar Mill Cr.	Sunset Valley
Weyerhauser	'49-'64	230	600	P	McKenzie	Springfield
Whitford-McKay	'57-'64	420	1,100	TF	Fanno Creek	Fanno Creek
Wilark Park	'65-'68	130	350	EA	Labisch Creek	Salem
Willamette Manor	'55-'63	530	1,000	P	Willamette	Oak Lodge
Wood Village	'43-'74	760	1,500	TF	Small Creek	Gresham

[a] 1 m^3/day = 264 gpd.

[b] Type of Plant:
TF - Trickling Filter
EA - Extended Aeration
L - Lagoon
AS - Activated Sludge
ST - Septic Tank
P - Primary Treatment
ISF - Intermittent Sand Filter

[c] Temporary Plant
[d] Via Truck
[e] 1942-1945 to 1951
[f] Before 1939 to 1949
[g] Original Plant: EA (1957)

Table 15. MAJOR OPERATING INDUSTRIAL WASTEWATER TREATMENT PLANTS

Plant and location	Type of process	Receiving stream river kilometer[a]	Allowable Discharges[b], kg/day[c]	
			BOD_5/Suspended Solids	Other[d]
American Can, Halsey	Bleached Kraft pulping and tissue wastes	Willamette - 238.8	1,100/3,200	None
Boise Cascade, St. Helens	Bleached Kraft pulping wastes	St. Helens STP to Columbia - 138.4	Discharge to St. Helens	None
Boise Cascade, Salem	Bleached sulfite pulping and fine paper wastes	Willamette - 135.5	3,600/3,200	None
Crown Zellerbach, Lebanon	Sulfite pulping and linerboard wastes	S. Santiam - 26.5	1,400/1,800	None
Crown Zellerbach, West Linn	Bleached groundwood pulping and fine paper wastes	Willamette - 42.5	1,800/3,600	None
Evans Products, Corvallis	Wet process hardboard wastes; battery separator plant wastes	Willamette - 212.7	900/1,600	None
General Foods - Birds Eye, Woodburn	Fruit and vegetable processing wastes	Pudding - 43.4	110/110	None
Kaiser Gypsum, St. Helens	Groundwood pulp and hardboard wastes	Scappoose Bay - 1.1	410/910	None
Oregon Metallurgical, Albany	Titanium processing wastes	Oak Creek to Willamette - 192.6	0/70	Chlorides - 4,500 Fluorides - 9,000

Table 15 (continued). MAJOR OPERATING INDUSTRIAL WASTEWATER TREATMENT PLANTS

Plant and location	Type of process	Receiving stream river kilometer[a]	Allowable Discharges[b], kg/day[c]	
			BOD_5/Suspended Solids	Other[d]
Pacific Carbide & Alloys, Portland	Calcium carbide electric furnace scrubber wastes and contaminated storm waters	Columbia Slough	0/[e]	None
Pennwalt, Portland	Contaminated cooling water from chlor-alkali process	Willamette - 11.9	0/0	Chlorine - 45 Chromium - 45 Ammonia - 70
Publishers Paper, Newberg	Bleached sulfite, unbleached groundwood pulping, and papermill wastes	Willamette - 80.4	2,700/3,400	None
Publishers Paper, Oregon City	Bleached sulfite and bleached groundwood pulping wastes	Willamette - 44.2	3,600/3,400	None
Rhodia, Portland	Process waste from insecticide production	Willamette - 11.3	0/120	COD[f] - 680 Dissolved solids - 21,000
Stimson Timber, Forest Grove	Groundwood pulping and hardboard wastes	Scoggins Cr - 6.4 to Tualatin - 101.0	No discharge[b]	None
Tektronix, Beaverton	Electroplating wastes	Beaverton Cr - 10.8 to Rock Cr. to Tualatin - 61.9	0/110	Ammonium Ion - 4.5 Fluoride Ion - 3.4

Table 15 (continued). MAJOR OPERATING INDUSTRIAL WASTEWATER TREATMENT PLANTS

Plant and location	Type of process	Receiving stream river kilometer[a]	Allowable Discharges[b], kg/day[c]	
			BOD_5/Suspended Solids	Other[d]
Union Carbide, Portland	Ferro alloys - electro furnace scrubber wastes	Columbia Slough	0/62	Manganese - 5.7 Cyanide - none detectable
Wah Chang, Albany	Process waste from exotic metals production	Truax Cr - 3.2 to Willamette - 185.8	0/320	COD[e] - 450 Dissolved solids- 22,000 Ammonium ion -1,400
Western Kraft, Albany	Unbleached Kraft, neutral sulfite semi-chemical pulping and linerboard wastes	Willamette - 187.4	1,100/2,300	None
Weyerhauser, Springfield	Unbleached Kraft pulping and linerboard wastes	McKenzie - 23.7	1,400/4,500	None

[a] 1 kilometer = 0.622 miles

[b] During low flow period; higher levels during winter.

[c] 1 kg = 2.20 lb.

[d] Inorganic waste streams have many other components.

[e] 50 mg/l suspended solids.

[f] COD - Chemical Oxygen Demand

investigation was limited to the twenty listed firms mainly because of the lack of information regarding expenditures for most other companies. This lack of data is not critical, however, to the objectives of this study. Of all industries having organic wastes--pulp and paper, wood products, food processing--and having their own outfalls, the pulp and paper related firms listed in Table 15 account for about 85 percent of the raw BOD_5 produced and 95 percent of that released to the Willamette River and its tributaries. Also, a check of capital expenditures for industrial pretreatment facilities showed these costs to be extremely low in comparison to the capital costs of the municipal systems to which discharge was made.

Table 16 summarizes pertinent information for existing and authorized federal reservoirs in the Willamette Valley. The existing reservoirs, all operated by the U. S. Army Corps of Engineers, are the ones of concern to this report. Reservoirs belonging to private industry and utilities (e.g., the Eugene Water and Electric Board) have been excluded from this study because they were felt to have a negligible flow augmentation impact when compared to the federal reservoir system. The Scoggins Creek reservoir presently under construction by the Bureau of Reclamation was not considered because this report dealt with the years prior to 1975,

ECONOMIC EXPENDITURES

Figures 14 and 15 represent the capital expenditures made for water pollution control by municipalities during the periods 1914-1945 and 1946-1974, respectively. The expenditures shown are total project costs and no attempt has been made to separate public and private "shares" in those cities where significant amounts of industrial wastes are handled by the municipal system. Municipal cost data was gathered from OSSA and the DEQ annual[45-51] and biennial[52-64] reports, the Environmental Protection Agency's (EPA) Project Register of Construction Grants[65-66], and the results of a Water Resources Research Institute (WRRI) municipal survey.

Figure 16 shows the capital expenditures for in-plant modifications and end-of-the-line treatment facilities made by industry since 1949. The total costs of industrial expenditures which aided water quality and also reduced operational costs (e.g., base conversions and chemical recovery systems at pulping companies) are included in this figure. No allocation of expenditures between these purposes was made. Thus, the industrial expenditures shown may be high. Industrial information came from the OSSA and DEQ reports, a review of DEQ's tax credit files, and a WRRI industrial questionnaire.

Table 16. FEDERAL RESERVOIRS IN THE WILLAMETTE VALLEY

Subbasin reservoir	Stream kilometer[a]	Drainage area km²[b]	Capacity, 1000m³[c] total	Capacity, 1000m³[c] usable	Authorized purposes[d]	Type of dam	Year operational	Generating capacity, kW
Tualatin[e]								
Scoggins Cr.[f]	Scoggins Cr. 8.2		75,000	65,000	WQC, FC, I, R, M&I, F&W		1975	None
McKay Cr.[g]	McKay Cr.			23,800				None
Rock Cr.[g]	Rock Cr.			4,700				None
Santiam								
Detroit	N Santiam 79.3	1130	561,000	419,000	FC, N, I, P	Concrete	1953	100,000
Big Cliff	N Santiam 74.7	1170	7,310	2,960	P, RR	Concrete	1953	18,000
Foster	S Santiam 60.7	1280	75,000	41,400	FC, P, RR	Rock Fill	1966	20,000
Green Peter	M Santiam 9.2	717	530,000	411,000	FC, N, I, P	Concrete	1966	80,000
Cascadia[g]	S Santiam 77.2			179,000	FC, N, I			None
Calapooia								
Holley[g]	Calapooia 73.2			110,000	FC, N, I			None
McKenzie								
Cougar	S Fk McKenzie 7.2	539	271,000	204,000	FC, N, I, P	Rock Fill	1963	25,000
Strube[g]	S Fk McKenzie 4.0			3,700	P, RR			39,500
Blue River[h]	Blue R. 2.7	230	110,000	104,000	FC, N, I	Rock/Gravel	1968	None
Gate Cr.[g]	Gate Cr. 0.6			62,000	FC, N, I			None
Long Tom								
Fern Ridge	Long Tom 41.4	707	124,800	136,000	FC, N, I	Earth	1941	None
Mid Fork								
Look Out Point	M Fk Willam. 32.0	2570	562,000	431,000	FC, N, I, P	Earth/Concrete	1954	120,000
Dexter	M Fk Willam. 27.0	2590	30,000	5,900	P, RR	Earth/Concrete	1954	15,000
Hills Creek	M Fk Willam. 72.2	1010	439,000	307,000	FC, N, I, P	Earth/Gravel	1961	30,000
Fall Creek	Fall Cr. 11.6	477	154,000	142,000	FC, N, I	Rock Fill	1965	None
Coast Fork								
Cottage Grove	C Fk Willam. 47.8	269	41,000	37,100	FC, N, I	Earth/Gravel	1942	None
Dorena	Row R. 12.2	686	95,600	87,000	FC, N, I	Earth	1949	None

[a] 1 Kilometer = 0.622 mile.
[b] 1 km² = 0.386 miles².
[c] 1,000m³ = 0.811 acre feet.
[d] FC-Flood Control; N-Navigation; I-Irrigation; P-Power; R-Recreation; M&I-Municipal and Industrial F&W-Fish and Wildlife; WQC-Water Quality Control; RR-Reregulating.
[e] Tualatin Reservoirs: Bureau of Reclamation; all others: Corps of Engineers.
[f] Under construction.
[g] Authorized.
[h] Two dams involved: a main dam and an auxiliary dam.

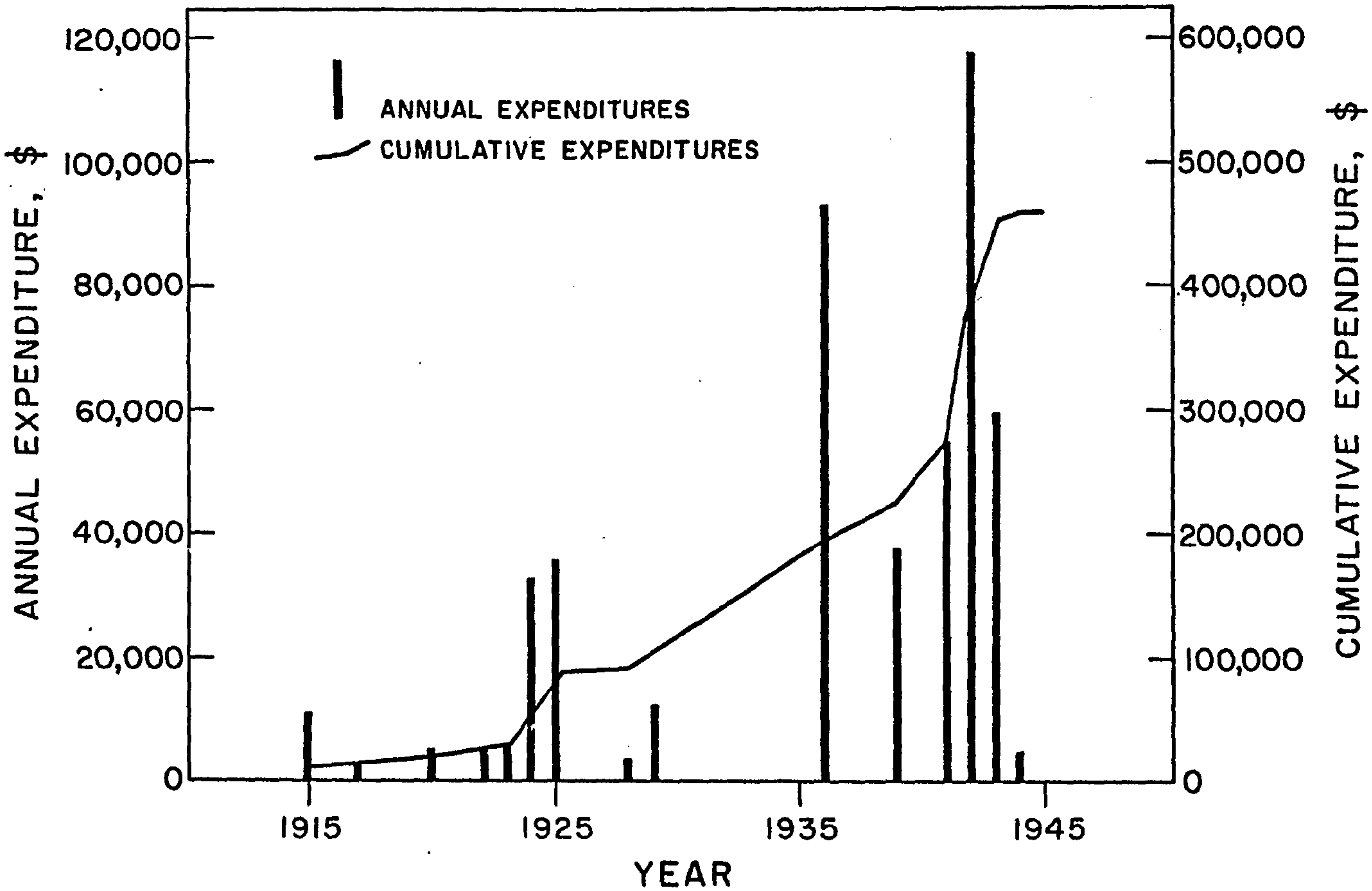

Figure 14. Capital expenditures for municipal sewage collection and treatment: 1915-1945.

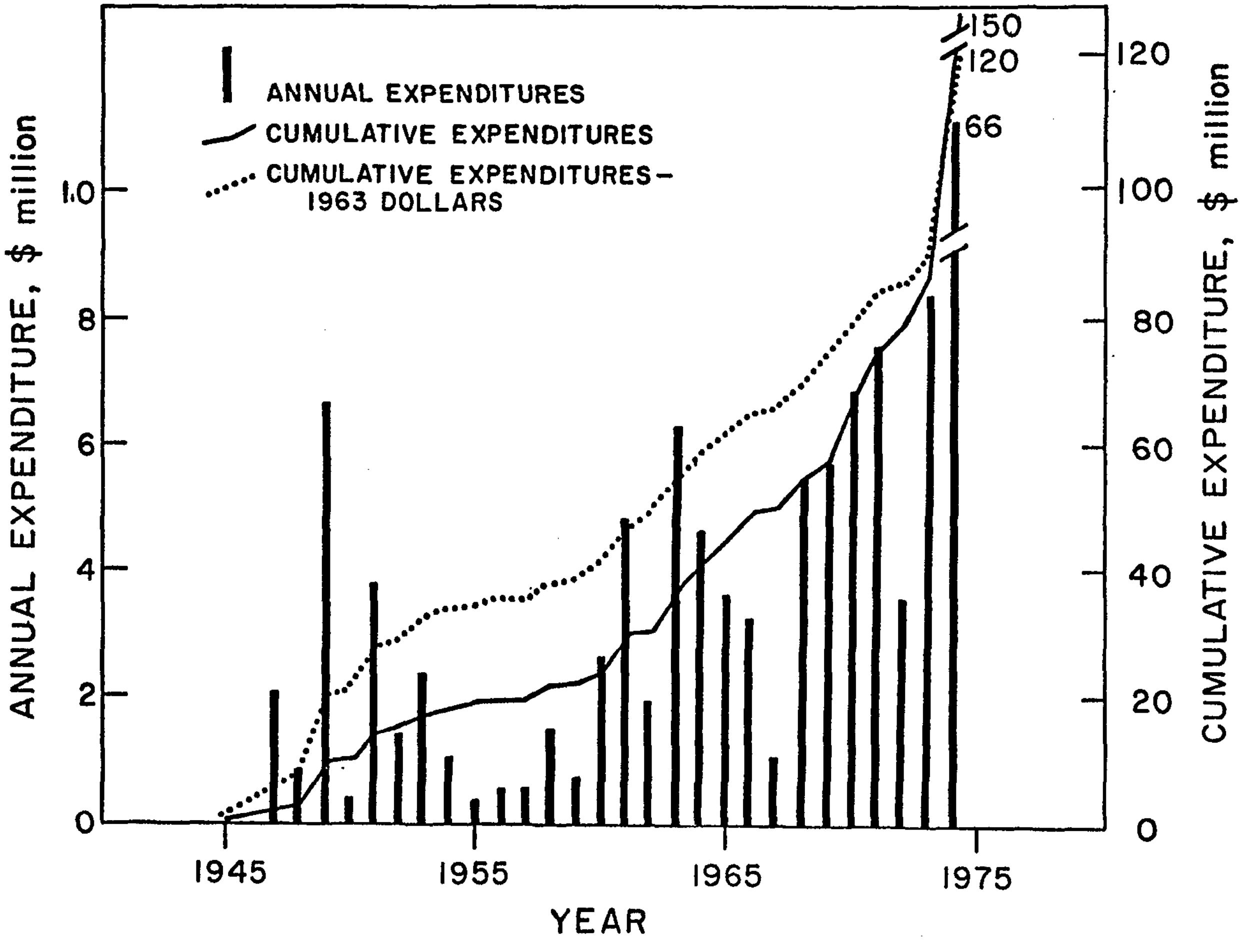

Figure 15. Capital expenditures for municipal sewage collection and treatment: 1946-1974.

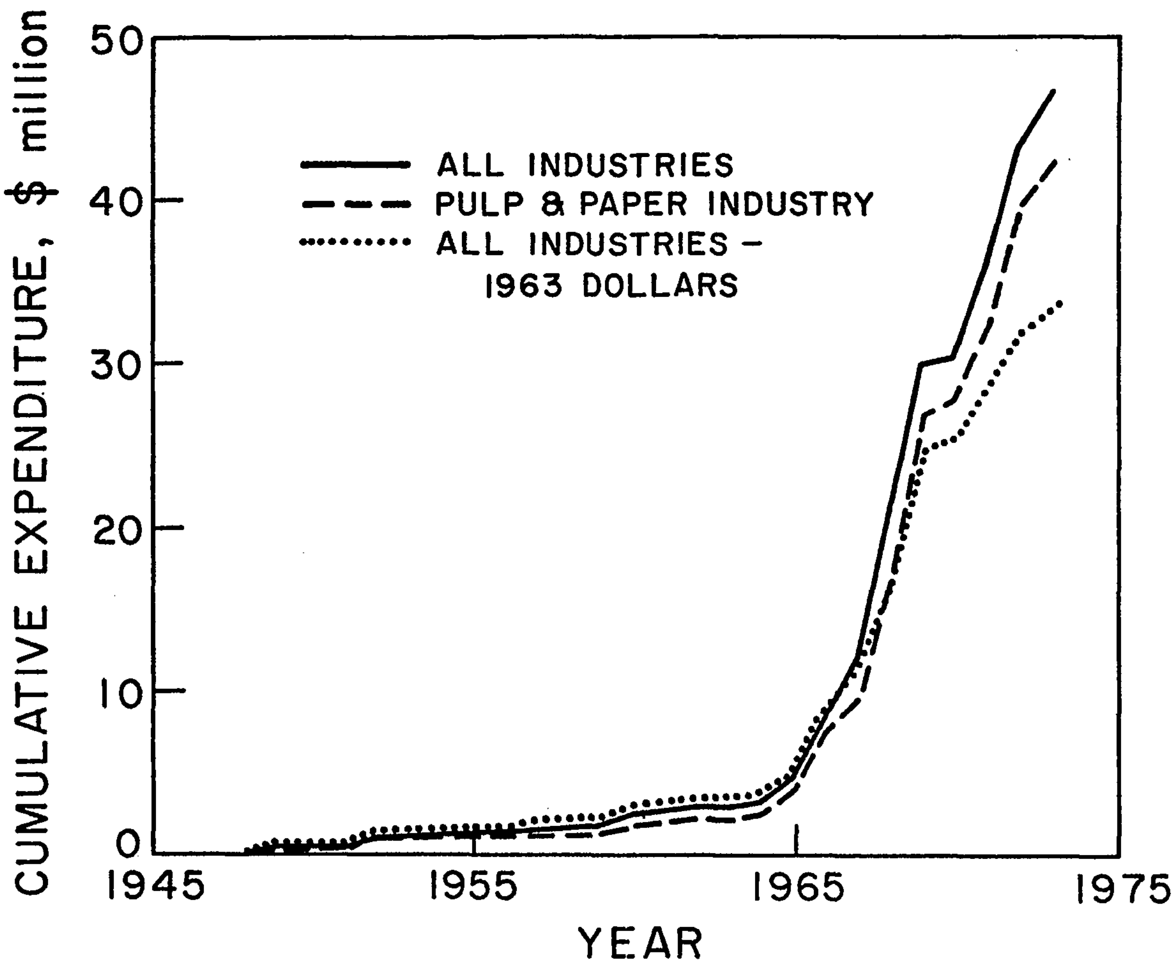

Figure 16. Capital expenditures for the control of industrial wastewaters: 1949-1974 (by the firms listed in Table 8).